Weather temperatures and sudden infant death syndrome: a regional study over 22 years in New Zealand

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Abstract

Study objective—To examine and identify relationships between the sudden infant death syndrome (SIDS) and environmental temperature in Canterbury, New Zealand.

Design—A retrospective epidemiological study combining details of regional hourly temperature and reported SIDS cases.

Setting—Canterbury, New Zealand, between 1968 and 1989 inclusively.

Participants—All infants reported as dying from SIDS within the Canterbury region.

Main results—The SIDS incidence increased after months with prolonged colder minimum temperatures, confirming the seasonality of SIDS. After adjusting for this seasonality, days that showed little change in hourly temperature and days with warmer minimum temperatures recorded were seen to have a significantly increased the incidence of SIDS. No evidence was found for other relationships between the SIDS incidence and various measures of daily temperatures on the day of death, over the preceding eight days or between these days. Infants aged 12 weeks and over were more susceptible to SIDS on days when small hourly temperature changes were recorded than their younger counterparts; no other age differences emerged.

Conclusions—This study confirmed that the incidence of SIDS is affected by seasonality and temperature on the day of death. In particular, after a prolonged period of cold minimum temperatures, infants were most at risk from SIDS on days on which either a warmer minimum temperature or little hourly variation in temperature were recorded. No other daily or lagged daily temperature factor (lagged up to eight days before the day of death) was statistically associated with the SIDS incidence. It is suspected that the inconsistent previously published lag effect findings actually describe some other phenomenon such as parental behaviour or infant thermoregulation.

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The sudden infant death syndrome (SIDS or cot death) is the sudden and unexplained death of an infant. One of the consistent epidemiological features of SIDS found throughout the world is that of seasonality—SIDS is more frequent in the winter months. This seasonal incidence of SIDS has led to speculation that local climate and weather patterns might be important precipitating factors for SIDS.

Several studies have reported relationships between SIDS and the environmental temperature over and above any seasonal effects. Unfortunately, the relationships have not been consistent across these studies.[1-3] McGlashan and Grice examined the relationship between the Tasmanian SIDS occurrence and the monthly minimum temperature, daily minimum temperature, and the difference between daily minimum temperatures on consecutive days (measured in Hobart).[1] They concluded that there was a significant decrease in the number of SIDS in months with warmer minimum temperatures, and that SIDS occurred more often on "cold" days (when the minimum temperature was less than 8°C) and more frequently on days without a moderate change in minimum temperature from the preceding day (when the minimum temperature changed by less than 3°C). Neither of the latter two effects were controlled for seasonality in their analysis and hence these results could simply be just another way of crudely describing season. Moreover, McGlashan and Grice provide anecdotal evidence suggesting that older children were more susceptible to long term cold periods.

Murphy and Campbell used space-time clustering techniques and time series analysis to test the effects of weather (measured in London) on SIDS rates in England and Wales.[2] After filtering to remove the dominant seasonal effect, they uncovered a significant lag effect between SIDS and the rate of change of temperature 4-6 days earlier, and between SIDS and the minimum temperature recorded 2-6 days earlier, irrespective of infant's age at death.

Campbell went on to examine SIDS occurrences in New South Wales, Australia, using Poisson regression methods to look at the mean temperatures (measured in Sydney) on the day of death and the preceding 9 days.[3] He found a strong relationship between SIDS and the average daily temperature, but this was reduced when taking account of monthly variations. There was, however, a significant negative correlation between SIDS and a change in temperature between 4 and 8 days earlier, with a peak coefficient 6 days earlier. This phenomenon was strongest among older SIDS babies. Overall, they concluded that a change in

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temperature about the monthly average, and not an actual daily temperature change, resulted in a change in the SIDS rate.

The purpose of this study was to consider these published relationships on a complete data set collected over 22 years from 1968-89 in Canterbury, New Zealand.

Methods

HYPOTHESES

The hypotheses that were derived from the above studies to be tested upon this Canterbury data set were as follows:

- Season effects: increased SIDS incidence is seen after months with colder minimum, mean, and maximum temperatures.
- Day effects: certain characteristics of minimum, mean, and maximum daily temperatures recorded on the observational day or over the preceding 8 days are associated with an increase in the number of SIDS after adjusting for season.
- Variation within day effects: the rate of change of temperature during the designated day and the preceding 8 days is associated with SIDS, over and above seasonal effects.
- Variation between day effects: the rate of change of temperatures between successive days preceding and including the designated day is associated with SIDS, over and above seasonal effects.
- Infant age difference: that infants dying from SIDS between the ages 12-52 weeks were more susceptible to temperature variations than their younger counterparts.

CANTERBURY COT DEATHS

All infant deaths occurring in the Canterbury region have been systematically examined since 1968, and those infant deaths attributed to cot death labelled as SIDS.[4-6] For the period 1968-89, there were 786 postneonatal infant deaths, 567 (72%) of which were classified as SIDS. All SIDS deaths that occurred in the Canterbury geographical region were included in the data set, whether or not the babies had been born in the region. Most (90%) of these deaths occurred within a 20 km radius of Christchurch Airport, the site of the meteorological measurements.

The infant's day of death was ascertained from pathology records and parent interview notes which documented the time and day that SIDS victims were first discovered. Few deaths were discovered before 6 am (5.0%). Most SIDS deaths were discovered between 7:30 am and 8:30 am (17.8%); otherwise SIDS deaths were discovered at a similar rate over diurnal hours. Nelson *et al*, studying postneonatal mortality in this region over this time, reported that two thirds of parents last saw their infants alive within six hours of the time that the infant was subsequently found dead.[7] This suggests that only a small proportion of SIDS infants would be misclassified in terms of their day of death.

KEY POINTS
- The incidence of sudden infant death syndrome (SIDS) increased after months in which there were prolonged colder minimum temperatures, confirming the seasonality of SIDS.
- After adjusting for seasonality, days with a warmer minimum temperature or with little temperature change also had a higher incidence of SIDS.
- No other temperature variables on the day of death, or over the preceding eight days, were significantly associated with an increased incidence of SIDS.
- Previously identified short term temperature effects could simply be a result of parental behaviour, infant thermoregulation, or the periodicity of weather patterns.

The highest number of SIDS victims recorded on any one day over the period of the study was two.

CANTERBURY WEATHER DATABASE

The New Zealand Meteorological Service supplied hourly recordings of temperatures measured to the nearest degree Celsius (°C) at Christchurch Airport for the years 1968-89. This airport is a well exposed site which is considered to be representative of weather conditions on the Canterbury Plains; the area in which most SIDS deaths occurred. Night minimum temperatures are around 1-2°C lower than in areas of high population density in the colder half-year, because of the "heat island" effect. The climate of the Christchurch area is very homogeneous, apart from the hills to the south where few SIDS deaths occurred.

From these hourly temperature recordings the daily measures of the minimum, mean, and maximum temperatures and temperature variations (ie range; SD; maximum hourly change; mean of the absolute hourly change, and SD of the hourly change) were calculated. A day was defined to contain the 24 hourly temperature measurements beginning from midnight. In order to examine the hypotheses relating to a lag effect of environmental temperature, variables were derived for minimum, mean, maximum, and variation measurements lagged from 1 to 8 days for each of the 8036 days of observation. For each of these variables "between day" measures were also determined by comparing measurements between adjacent days.

Three seasonality indicators were defined by taking 31 day averages of the minimum, mean, and maximum temperatures, calculated for each of the 8036 observation days. As it is the preceding weather patterns which should affect SIDS incidence (and not temperatures after death), these seasonality indicators were composed by averaging the relevant temperature measurements for 30 days before and the day including each designated observational day. These 31 day averages were then used in ensu-
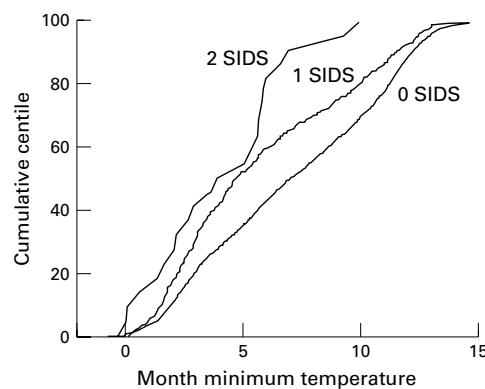
Figure 1 Thirty one day average of minimum daily temperatures (min31) grouped by categories of sudden infant deaths per day.

ing analyses to represent long term seasonal weather patterns.

ANALYSIS
Specific pair-wise comparisons between cumulative temperature distributions were made through the implementation of the two sample, Kolmogorov-Smirnov test.[8]

The Statistical Analytical System (SAS Institute Inc) was used to examine each hypothesis through the implementation of logistic regression (LOGISTIC) and general linear model (GLM) procedures. Ordinal logistic regression was employed to cater for the ordinal nature of daily SIDS occurrence.[9][10] In particular, each of the 8036 days had SIDS numbers classified by response categories: 1=days without SIDS; 2=days with one SIDS occurrence; and 3=days with two SIDS deaths. No day had more than two SIDS deaths. Ordinal logistic regression models relating temperature to SIDS incidence were developed by selecting those temperature variables which significantly improved the log-likelihood statistic over the baseline model.[11][12] As temperature was recorded in degrees Celsius, reported odds ratios can be interpreted as the risk of a SIDS death if the temperature rises by 1°C.

Under the assumption of normality, the common variance test for two populations, H_0: $\delta^2_i = \delta^2_j$, was formally made by calculating the test statistic $F = s^2_i / s^2_j$ and comparing it against the $F(n_i-1, n_j-1)$ distribution, where s^2_i and n_i are the sample variance and sample size of population i, respectively. Tests between group means were made using ANOVA when the assumptions of normality and common variance were met.

It should be noted that day0 is defined to correspond to the designated day, while day-1 represents the preceding day, day-2 is the day preceding day-1, and so forth. Because of the high degree of serial correlation between lagged daily temperature variables, each variable was included separately into the model.

The results are presented in the order of the hypotheses examined.

Results
Over the 22 years of the study (8036 days) there were 545 days (6.8%) on which one or more SIDS occurred: no SIDS occurred on

7491 days (93.2%); one SIDS occurred on 523 days (6.5%); and two SIDS occurred on the remaining 22 days (0.3%).

HYPOTHESIS 1: SEASON EFFECTS
Seasonality measures embody a description of long term weather patterns; typically a *month* is considered long term. Measures of seasonality investigated in this study were derived by taking 31 day averages of daily minimum, mean, and maximum temperatures (denoted hereafter as min31, mean31, and max31, respectively). A high degree of association existed between these measures (Pearson correlation: min31 and mean31 $r=0.983$; min31 and max31 $r=0.947$; and, mean31 and max31 $r=0.988$). Ordinal logistic regression was used to ascertain which measure of seasonality best explained SIDS, through comparison of log-likelihood values. Seasonality measured by min31 yielded a log-likelihood value of -2050.3, which was better than mean31, with a log-likelihood of -2051.2, and max31, with a log-likelihood of $-2,054.1$ (each of the three seasonality measures satisfied the proportional odds assumption using the Score test at $\alpha=0.05$.

Upon further examination of the regression, it was evident that the effect of seasonality measured by min31 was statistically important. The log-likelihood for the intercept only model was -2084.8 and when min31 was introduced it was -2050.3, resulting in G=68.9 which, approximated by the χ^2 distribution with 1 df, gave rise to p<0.001. These results demonstrated that seasonality measured by min31 was strongly associated with SIDS, thus all remaining analyses that required a seasonality component used this measure.

The parameter estimate and standard error (SE) associated with min31 in the regression model was ($=0.099$ (SE 0.012). This parameter estimate indicates that for every increase of 1°C in min31 temperature, the associated risk of SIDS decreased by 0.906 times. In terms of the absolute SIDS risk, noting that the model's intercept estimates were ($_1=1.996$ (SE 0.083) and $\chi^2=5.282$ (SE 0.224), the odds of recording one SIDS death was just over 1 in 7 on days with temperature min31=0°C. At min31=5°C this risk decreased to 1 in 12, while at min31=10°C the risk decreased further to 1 in 20. Similarly, the absolute risk of two SIDS occurrences was 1 in 199 on days with temperature min31=0°C, 1 in 328 at temperature min31=5°C, and for min31=10°C the risk of two SIDS deaths decreased to 1 in 541.

Figure 1 depicts the cumulative frequency distribution of min31 temperatures (the 31 day average of minimum daily temperatures) by SIDS categories. From this graph it is clear that SIDS deaths were affected by min31 temperatures. The discrepancy between min31 temperature curves can be statistically substantiated by the two-sample Kolmogorov-Smirnov test with pair-wise comparisons between: 0 SIDS days and 1 SIDS days curves yielding D=0.176 resulting in p<0.001; 0 SIDS days and 2 SIDS days curves yielding D=0.416 resulting in p=0.001; and 1 SIDS days and 2

No of SIDS deaths	Days	Mean	(SD)
0	7491	7.018	(3.799)
1	523	5.692	(3.665)
2	22	4.176	(2.728)

SIDS days curves yielding D=0.257 resulting in p=0.123. These results indicate that days on which one or two SIDS deaths occurred had a significantly lower min31 temperature than days on which there were no SIDS deaths. Although days where two SIDS occurred appeared to have lower min31 temperature measurements compared with days with a single SIDS occurrence, this received little statistical support as the numbers associated with these incidences were small.

It is interesting to look at the mean(SD) of the min31 temperatures grouped by SIDS numbers, as shown in table 1. The mean min31 temperature decreased as the number of SIDS deaths per day increased, confirmed by analysis of variance (ANOVA: F-value=35.7, df=2, p<0.001). Indeed, the mean min31 temperature for days on which two SIDS deaths occurred was some 3°C lower than in days which were free of SIDS deaths. Moreover, it seems that the variability of the min31 temperatures decreased as the number of SIDS per day increased (particularly on the days which recorded two SIDS victims). However, this decrease lacked statistical support at the α=0.05 level.

HYPOTHESIS 2: DAY EFFECTS
Ordinal logistic regressions were performed to ascertain the effect of minimum, mean, and maximum daily temperatures for each observation day (day0) and the preceding 8 days (day-1 to day-8) on the incidence of SIDS.

Since a high degree of association existed between the seasonality measure (min31) and daily minimum, mean, and maximum temperatures (Pearson correlation: r=0.756; r=0.781; and r=0.674, respectively), it was necessary to remove seasonality from these daily temperature measures. This adjustment was achieved by subtracting the seasonal component (min31) from each corresponding daily measurement for all 8036 days, thereby giving adjusted daily temperature measures which had nominal association with min31 measures (Pearson correlation: r=−0.042; r=−0.042; and r=−0.010, respectively). Moreover, as daily temperature measurements typically exhibit a high degree of serial correlation, separate regressions were conducted on the observational day (day0) and each preceding day (day-1 to day-8) for each adjusted minimum, mean, and maximum daily temperature.

Assuming a significance level of α=0.05, only the adjusted minimum temperature on day0 (denoted hereafter as minday0) provided any statistical evidence for affecting the rate of SIDS over and above seasonality. Recalling that the log-likelihood of the model containing only min31 seasonality was −2050.3, when the minday0 temperature was added the log-likelihood fell to −2048.4, resulting in G=3.9 and corresponding p=0.049 (there was no evidence to reject the proportional odds assumption as the Score test p=0.189). Table 4 contains the relevant statistics associated with this analysis, denoted as "model 1." These results indicated that for each rise of 1°C in min31 temperatures, the risk of SIDS *decreased* by 0.907 times, and for minday0 temperatures, the risk of SIDS *increased* by 1.028 times. This suggests that the greatest risk for SIDS occurred when there was a *low* min31 temperature and a *high* minday0 temperature—or more simply, on warmer days in winter.

To gain a further insight into the effect of the adjusted minimum temperature on day0 (minday0), this variable was divided into five convenient subgroups of approximately equal size and temperature width of 2°C. Measures of the proportion of SIDS per day and the mean daily temperature were determined for these groups and these findings are shown in table 2.

It is evident that days with minimum temperatures exceeding the 31 day average of minimum daily temperature by more than 3°C had, on average, an increased SIDS risk (8.3 per 100 days). By contrast, the SIDS risk for days recording minimum temperatures below this level seemed to be reasonably stable (approximately 6.8 per 100 days). In addition, adjusted minimum temperatures were generally positively associated with mean daily temperatures (Pearson correlation r=0.432). This makes intuitive sense as it seems unlikely that days with high adjusted minimum temperatures would have recorded low mean hourly temperatures.

No other regression model using minimum day-1 to day-8 or mean and maximum day0 to day-8 daily temperature variables was seen to improve the model containing only min31 seasonality (at α=0.05).

HYPOTHESIS 3: VARIATION WITHIN DAY EFFECTS
Again, ordinal logistic regressions were performed to ascertain the affect of various daily temperature variability measures on the incidence of SIDS. The daily variability measures used were: range; SD; maximum of the absolute hourly changes; mean of the absolute hourly changes; and SD of the absolute hourly changes. An *absolute hourly change* was defined as the absolute value of the difference between two consecutive hourly temperatures. Absolute

Minday0 grouping (°C) *	No	Mean daily temperature (°C)	SIDS per 100d
≤ −3	1479	8.47	6.3
−3 - −1	1566	10.19	7.1
−1 - +1	1785	11.68	6.9
+1 - +3	1789	13.06	6.8
>3	1417	14.32	8.3

* Minday0 is the difference between minimum daily temperatures and their associated 31 day average of minimum temperatures.

hourly changes were used as it was the magnitude of variation that was considered important and not necessarily the direction of the movement. These variation measures were investigated for each observation day (day0) and the preceding 8 days (day-1 to day-8) on the incidence of SIDS. Because of serial correlation between measured days, separate regressions were again employed to ascertain individual day effects for these temperature variations, after controlling for seasonality.

At significance level $\alpha=0.05$, mean absolute hourly temperature changes on day0 (denoted hereafter as meanHTCday0) were seen to affect the rate of SIDS. This model had an associated log-likelihood of -2047.8 which, when compared to the model containing min31 seasonality having log-likelihood -2050.3, produced a G=5.2 and corresponding p=0.023 (the proportional odds assumption was satisfied as the Score test p=0.196). Labelled as "model 2," table 4 delineates the relevant output from this analysis. These results indicate that for each rise of 1°C in:

- min31 temperatures, the risk of SIDS *decreased* by 0.905 times
- meanHTCday0 temperatures, the risk of SIDS *decreased* by 0.759 times.

This implies that the greatest risk for SIDS occurred when there was a *low* min31 temperature and *low* meanHTCday0 temperature; or more simply, on winter days that had little temperature change.

To develop a better understanding of the mean absolute hourly temperature change on day0 (meanHTCday0), this variable was partitioned into five convenient subgroups of approximately equal size and temperature width of 0.25°C. Again, measures of the proportion of SIDS deaths per day and the mean daily temperature were determined for these groups. These results are shown in table 3.

Days within the smallest mean absolute hourly temperature change category ((0.50°C) had a raised risk of SIDS (8.9 per 100 days) while days recording mean absolute hourly temperature changes > 0.50°C seemed to have a reasonably constant SIDS risk (approximately 6.7 per 100 days). It is evident too that the days on which there was little hourly variation generally occurred at lower mean daily temperatures (10.69°C) than days with larger hourly variation (up to 13.05°C), although this association was relatively small (Pearson correlation r=0.156). The association between mean daily temperatures and mean absolute hourly

Table 3   The number, mean daily temperature, and rate of sudden infant death sysndrome (SIDS) deaths grouped in relation to mean absolute hourly temperature changes on day 0 (meanHTCday0) in Christchurch, New Zealand, 1968-89

MeanHTCday0	No	Mean daily temperature (°C)	SIDS per d
≤0.50	1416	10.69	8.9
0.50 - 0.75	1838	11.34	6.6
0.75 - 1.00	1882	11.34	7.0
1.00 - 1.25	1614	11.69	6.5
>1.25	1286	13.05	6.4

temperature change values is intuitively reasonable as it is unlikely that days on which a high temperature was recorded would maintain high and unvarying temperatures over each of the 24 hourly measurements throughout the day and night.

No other regression using mean absolute hourly temperature changes for day-1 to day-8, or regressions using the previously described temperature variation within day measures for day0 to day-8, resulted in a model that reached statistical significance at $\alpha=0.05$.

HYPOTHESIS 4: VARIATION BETWEEN DAY EFFECTS
Using identical logistic procedures, the effect of temperature variations between successive days was examined on the rate of SIDS, after controlling for min31 seasonality. The particular measures used to describe variations in temperature between day0 and day-1, day-1 and day-2, and so forth, were daily minimum, mean, maximum, range, SD, maximum absolute hourly changes, mean absolute hourly changes, and SD of the absolute hourly changes. Separate analyses were conducted for each measure and adjacent day combination to avoid serial correlation.

None of the examined regressions yielded a model that reached statistical significance at $\alpha=0.05$. Thus, temperature changes from day to day seemed to have little affect on SIDS risk.

HYPOTHESIS 5: INFANT AGE DIFFERENCE
SIDS infants aged less than 12 weeks at death were considered younger infants while those who were at least 12 weeks of age at death were deemed older. From this definition there were 230 (40.6%) younger and 337 (59.4%) older infants who were considered as SIDS deaths.

Temperature comparisons between infant age categories were made by investigating the cumulative frequency distributions of the previously identified, statistically important temperature measures—namely min31, minday0, and meanHTCday0. Two-sample Kolmogorov-Smirnov tests detected no difference in min31 (D=0.091 yielding p=0.210) and minday0 (D=0.029 yielding p=0.400) temperatures between younger and older infants. However, as depicted in figure 2, an age differential emerged in meanHTCday0 temperatures between older infants and their younger counterparts (D=0.116 yielding p=0.050).

This result was reinforced by noting the difference between average meanHTCday0 temperatures. The average meanHTCday0 temperature for younger SIDS infants was 0.902°C (SD 0.383), compared with 0.821°C (SD 0.382) for older infants (t=2.459, df=565, p=0.014).

AN APPROPRIATE TEMPERATURE MODEL
From the preceding analyses, summarised in table 4, it seems that seasonality (min31) and both the minimum temperature (minday0) and the mean absolute hourly temperature change (meanHTCday0) on the day of observation affected the likelihood of a SIDS death occurring on a particular day. There was a small and
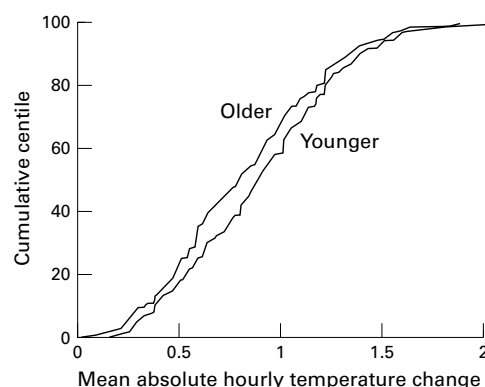
Figure 2 Mean absolute hourly temperature changes on day0 (meanHTCday0) for younger and older infants who died from sudden infant death syndrome.

negative association between minday0 and meanHTCday0 temperatures (Pearson correlation $r = -0.291$).

Table 4 shows that the better model containing two variables was "model 2," which includes min31 and meanHTCday0 temperatures, as this model recorded a log-likelihood statistic of -2047.8 which was superior to the -2048.4 recorded when temperature model "model 1" was adopted. When all three variables were introduced together into the regression, the resultant log-likelihood statistic equalled -2046.9. Comparing this with the best two variable model, namely model 2, gave $G = 1.7$ and $p = 0.188$. This suggests that using all three variables does not significantly improve the temperature model over model 2.

Finally, a model including an interaction term between min31 and the mean HTCday0 temperatures was considered. Little statistical support for an interaction term was found with this model—it recorded a log-likelihood value of -2046.4, $G = 2.6$, and a corresponding $p = 0.107$.

The most parsimonious temperature model, based upon these investigations, should utilise both the 31-point mean of the minimum daily temperatures preceding and including the observational day and the mean absolute hourly change in temperature on the observational day.

Discussion

Motivation for this study stemmed from the inconsistent and often non-intuitive findings detailed in several recent publications. Using new SIDS and weather data, analyses were conducted in an effort to substantiate or refute these findings.

Over the time frame of this study there has been careful ascertainment of SIDS diagnosis and the diagnostic criteria applied have been constant.[4][13] A feature of our data is the change in cot death rates—SIDS became almost "epidemic" in the latter years, amounting to one of the highest recorded incidences in the western world.[4][14] Under these conditions, weather effects might be more evident.

Among the notable strengths of this study is the utilisation of a weather data set spanning 22 years, compared with only five to seven years of the other studies.[1-3] The complete database contained the entire set of hourly temperatures officially recorded by the meteorological office. This enabled the accurate determination of those temperature measurements investigated in this study for every single day over the 22 year period. Moreover, appropriate and accurate long term "monthly" seasonal effects were easily ascertained by taking averages of the relevant daily temperatures over the observational day and the 30 days immediately before that day. Long term seasonality measures derived in this manner avoided the inherent deficiency associated with the typically adopted *calendar month* measures in that temperatures occurring after each observational day or SIDS death were never used.

The localisation of SIDS deaths around the point of temperature collection is another strength of our study; nearly all SIDS deaths occurred within a 20 km radius of the meteorological station. The other studies took their weather measurements in one city (namely, London, Hobart, and Sydney) and extrapolated them homogeneously over the entire country or region of investigation (that is England & Wales, Tasmania, and New South Wales, respectively).[1-3] Clearly, many SIDS cases occurred hundreds of kilometres away from the point of temperature collection. While temperature assumptions of this kind will not unduly affect long term pattern estimations, one must question whether it is reasonable when investigating daily and lagged temperature effects.

In middle latitudes, the passage time of a weather change across the areas associated with the previous temperature studies is typically around 12-48 hours.[1-3] Furthermore, each of these regions has strong geographical relief, a factor which leads to an individual weather system producing strong variations in conditions over different locations. This implies that many locations within the country or regions of these studies would expect to record temperatures that were either discordant with or lagged from the actual temperatures used in analyses. Lag effects may also result from the cyclical influence of the prevailing climate pattern rather than any specific association with SIDS. For instance, over Tasmania, New South Wales, and New Zealand, there is roughly a weekly periodicity in the eastward progression of anticyclones and the intervening troughs. Perhaps the significant lagged temperature effects previously noted are simply manifestations of these phenomena?

The temperature range of described lagged effects is in the order of 1 or 2°C, which we believe is unlikely to have any significant biological repercussions.[2][3] Indeed, the mean interdiurnal variability of temperature in middle latitudes is about 2-3°C.

Our results provide no statistical evidence for a short term lag effect (up to eight days preceding a death) in any temperature measurement, in contrast to the small lag effects previously reported.[2][3] Instead, we have confirmed a strong seasonal effect and also the importance of the temperature on the day of a SIDS death. In

Table 4   Results of ordinal logistic regression analysis with G statistics which met the α=0.05 criterion.

	Temperature variables	Estimated coefficients	Estimated SD	Wald p value	Odds ratio (95% CI)
Model 1	min31	0.098	0.012	<0.001	0.907 (0.885, 0.929)
	minday0	−0.027	0.014	0.049	1.028 (1.00, 1.056)
	Log-likelihood statistic = 2048.4				
Model 2	min31	0.100	0.012	<0.001	0.905 (0.884, 0.927)
	meanHTCday0	0.276	0.121	0.023	0.759 (0.598, 0.963)
	Log-likelihood statistic = 2047.8				

particular, we showed that the minimum temperature on the day of death and the mean absolute hourly change in temperature on the day of death were both important effects that increased the likelihood of a SIDS death. Notably, the overall effect associated with the mean absolute hourly change in temperature was greater than the minimum temperature effect, and greater still for older infants. In both instances the statistically significant short term effects of temperature occurred within 24 hours of the death so it may be that changes in temperature during this period may have some more immediate conditioning on parental behaviour or infant thermoregulation. This conjecture needs further investigation.

We conclude that the major influence of weather on SIDS is related to long term patterns, with a small effect of the minimum temperature and mean absolute hourly change in temperature on the day of death. No evidence for lag effects of temperature on SIDS could be found.

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